REMARKS

The present response is intended to be fully responsive to all points of objection and/or rejection raised by the Examiner and is believed to place the application in condition for allowance. Applicants assert that the present invention is new, non-obvious and useful. Prompt consideration and allowance of the claims is respectfully requested.

Status of Claims

Claims 1-15, 17-19, 21-25, 27-51, 75 and 76 are pending. Claims 1-15, 17-19, 21-25, 27-51, 75 and 76 have been rejected.

Claims 1, 8, 11 and 32 have been amended herein. Applicants respectfully assert that the amendments to the claims add no new matter.

CLAIM REJECTIONS

35 U.S.C. § 103 Rejections

In the Office Action, the Examiner rejected claims 1-2, 5-15, 17-19, 32-35, 41-44, 46-50, 75-76 under 35 U.S.C. § 103(a), as being unpatentable over Cross (US Patent No. 4,777,338) in view of Tagaki et al (US Patent No. 6,348,675). Applicants respectfully traverse this rejection.

Cross discloses a method for spark perforating synthetic plastic film, comprising moving a plastic film to be perforated through a water bath that is kept at a defined temperature, positioning electrodes adjacent opposite the sides of the film in this water bath, and applying a pulsed electrical potential between the electrodes (see Cross, figure 2 and column 3, lines 49-57). The spark discharges are externally controlled by a trigger generator "at an appropriate repetition frequency according to the perforation spacing required" (see Cross, column 5, lines 10-12), and the size of the holes, most notably their diameter, is influenced by choosing an appropriate temperature of the water bath. According to column 3, lines 41-42, the holes have a smaller diameter, the higher the temperature of the water bath. At the same time, however, Cross also states that the purpose of the water bath is not so much applying additional heat to the system, but rather <u>removing heat</u> generated by the spark discharges between the electrodes (see Cross, at column 4, lines 37-41). Since the film is

transported through the water bath, the spacing and position of the holes applied is determined only by the frequency at which the electrical pulses are applied (see Cross, at column 5, lines 10-12).

As acknowledged by the Examiner, Cross does not disclose an electronic feedback mechanism comprising an analysis circuit, wherein the analysis circuit is either a current analysis circuit or a voltage and current analysis circuit, as recited in amended independent claim 1. Moreover, Cross does not disclose that the heat applied in step c) is applied in a directed at locally restricted manner, i.e., to the region only, where a hole or cavity or channel is to be formed, as recited in amended independent claim 1. Furthermore, Cross does not use the water bath "to define the location where dielectric breakdown is to occur", as recited in amended independent claim 1.

The position of the holes applied in Cross is solely determined by the position of the disks 60 and the frequency at which the electrical pulses are applied (see column 5, lines 10-12 of Cross), and the application of heat has no defining role for the position of the holes to be formed. This difference has the effect that, according to the present invention as recited in amended independent claim 1, a better control over the entire process of perforation is possible, holes of extremely high aspect ratio can be achieved (see for example figure 3b and figure 3e, the latter with an aspect ratio of approximately 50), the precise position and dimensions of a hole can be defined, and the process of dielectric breakdown can also be used with brittle substrates, such as glass.

Thus, it is evident that Cross is deficient for because Cross does not consider applying heat only locally, i.e., in a directed and locally restricted manner to the region only, in which a hole or cavity or channel is to be formed. The purpose of the water bath in Cross is to remove heat rather than to apply additional heat, since Cross explicitly states that *"the use of the water bath provides a convenient way of removing heat generated by the spark discharges between the electrodes, and the rate of water flow through the bath may be regulated to maintain a desired temperature"* (emphasis added) (see column 4, lines 37-41 of Cross). In other words, Cross does not apply additional heat to the substrate at all, by use of the water bath, but rather removes heat that has been generated by the spark discharges.

But, even if one were to accept that the use of the water bath corresponds to the application of additional heat to the substrate, Cross does not apply such heat in a directed and locally restricted manner, i.e., to the region only in which the hole is to be formed, as recited in amended independent claim 1. Rather, in Cross, as can be seen from Figure 2 thereof, the entire film is submersed in the water bath which means that any energy applied through such water bath is applied globally to the entire submersed film. Hence, Cross has not recognized the possibility of defining the position of the hole by the directed and locally restricted application of heat at all.

In addition, a directed and locally restricted application of heat, as recited in step c) of amended independent claim 1, also seems in contradiction to the teaching of Cross which aims at keeping the water bath *"at a temperature above the onset temperature of glass transition of the film material and selected to provide a desired perforation diameter"* (emphasis added) (see Cross, column 3, lines 63-65). Cross has not even recognized the use of the local application of heat as a means to define the position where a hole is to be formed. The entire teaching of Cross is directed at a uniform maintenance of temperature over the entire film.

Furthermore, Cross does not consider applying heat "so as to reduce the amplitude of voltage required in step b) to give rise to a current increase through the region", as recited in independent claim 1. Cross talks only about keeping the water bath "*at a temperature above the onset temperature of glass transition of the film material and selected to provide a desired perforation diameter*" (see column 3, lines 63-65 of Cross). The glass temperature Tg is typically defined as the temperature at which a transition of a liquid to a glassy state occurs and is commonly defined by a characteristic change in specific heat capacity as function of temperature or by a characteristic change in the volume expansion coefficient as function of temperature or sometimes by defining a threshold viscosity. The glass transition temperature is not related to the electrical conductivity of a substrate, and, hence, Cross does not consider using the application of heat through a water bath "so as to reduce the amplitude of voltage required in step b to give rise to said current increase". Therefore, Cross has not considered the focused application of heat as a means to locally influence conductivity of the substrate in the region where a hole is to be formed, and thus to facilitate the formation of holes.

Similarly, Cross does not consider the use of a feedback mechanism as an appropriate measure to influence the dimensions of the hole generated. Cross even explicitly states that *"the perforation size is relatively insensitive to the total energy of the discharge, provided that initial dielectric breakdown has been attained"* (see column 6, lines 11-13 of Cross). In contrast thereto, according to the present invention, a trans-substrate current is monitored by a current analysis circuit or a voltage and current analysis circuit, and the dielectric breakdown and dissipation of energy through discharges is thus precisely controlled. This is nowhere disclosed or suggested in Cross.

Takagi discloses a method of producing pores in a plastic film by feeding the plastic film into the spark gap between electrodes (see Figure 1 of Takagi). According to Takagi, a series of discharge sparks are generated, wherein initially, there is a "partial discharge spark" which only causes dielectric breakdown of the layer of air in the spark gap. Subsequently, there is a "pore-opening discharge spark" which causes a dielectric breakdown of the plastic film and the layer of air in the spark gap in such a way that a pore is created. Thereafter, further discharge sparks occur which are "penetrating discharge sparks" going through the pore in the plastic film and crossing to the earth electrode (see also column 2, line 62 – column 3, line 9 of Takagi). During the process of the generation of discharge sparks, the voltage at the upper electrode 4 is measured by a high-voltage probe 7 (see also Figure 1). According to Figure 2, during the partial discharge spark, the voltage of the upper electrode does not drop to ground level but only to position "A" in Figure 2. The voltage drops to the ground level in the subsequent "pore opening discharge spark", referred to as position "B" in Figure 2. The subsequent "penetrating discharge sparks" do not have a discharge voltage as high as the "pore-opening discharge spark" and thus achieve only levels referred to as "12" and "13" in Figure 2. The high voltage probe of Takagi measures the voltage of the upper electrode throughout the process and sends signals to the pulse generator 1 of Figure 1. The event of a pore-opening discharge spark is determined by measuring the voltage at the upper electrode. A voltage drop to a lower level than a defined threshold indicates that a hole was opened and thus defines the pore-opening discharge spark. It is then also possible to monitor and count the subsequent penetrating-discharge sparks which serve to increase the diameter of the pore: The diameter of the pores becomes steadily larger as the number of penetrating discharge sparks increases (see also column 3, lines 28-30 of Takagi). The diameter of the

pores can thus be controlled by cutting the pulse off at a time, when the desired number of penetrating discharge sparks after the pore-opening discharge spark have been detected (see column 3, lines 30-36 of Takagi).

Hence, what is measured in Takagi is a voltage, and the voltage is used to determine the number of pore-penetrating discharge sparks to define the diameter of the pores. Thus, the pore formation/widening occurs in discrete steps determined by the number of pore-penetrating discharge sparks. In a plastic film of a thickness of 30 µm, the pores thus achieved have a diameter between 30 and 50 µm, thus yielding an aspect ratio between 0.6 and 1, at best (see example 1, column 3, line 65 and column 4, line 11). In example 2, the aspect ratio thus achieved is between 30/70 = 0.43 and 30/200 = 0.15 (column 4, line 37). It should be noted that the relatively better aspect ratio of example 1 was achieved using the minimum number of penetrating discharge sparks, namely zero (see column 4, line 5 of Takagi). Using 2 discharge sparks, as in Example 2 (column 4, lines 16-17), the aspect ratio already deteriorates.

However, the claimed invention is not obvious over Cross in combination with Takagi, because Takagi does not remedy the deficiencies of Cross as set forth above., as discussed below.

First, Takagi does not consider using a current analysis circuit or a voltage and current analysis circuit as a feedback mechanism. Takagi purely measures voltage of the upper electrode and uses this to determine the number of penetrating discharge sparks after the pore-opening discharge spark in order to determine and define the size of the pores. The mechanism of Takagi is thus rather crude. As can be seen in the examples, the achieved aspect ratios are rather poor, and if a person skilled in the art was to learn something from Takagi, it is that the use of measurements of voltage in a feedback mechanism, this can be used to reproducibly form holes of a defined size, albeit at a rather poor aspect ratio.

Also, the method of Takagi cannot be applied to brittle substrates, such as glass, because it would lead to a breakage of the substrate (see explanations hereto in the present application, page 13, fourth paragraph of the WO-publication, explaining that *"without precise control of the current magnitude and duration, this current increase is usually too violent for the formation of small holes and other small structures. Furthermore, at*

voltages/electric fields sufficient to cause DEB under ambient conditions in rather brittle materials, such as glass, usually an irregular breaking of the substrate occurs, rendering the final substrate useless for most applications". In contrast thereto, in accordance with the present invention, the current across the substrate is monitored using a current analysis circuit or a voltage and current analysis circuit which allows better process control of the duration and intensity of the dissipation of electrical energy, thus enabling the formation of high aspect ratio holes, and furthermore, thus enabling the formation of such high aspect ratio holes in brittle substrates, such as glass (see various examples of the present application).

In addition, Takagi does not disclose the application of heat in a directed and locally restricted manner to the region only in which the hole is to be formed, as recited in amended independent claim 1. Takagi also does not use such directed and locally restricted application of heat to define the location where dielectric breakdown is to occur. This, again, makes the method of Takagi totally unsuitable for brittle substrates, and Takagi would fail in this context.

Even if one did combine Cross and Takagi, one with ordinary skill in the art would not arrive at the present invention, given that a combination of these two documents would not yield a method which would combine the directed and locally restricted application of heat (in step c) with a feedback mechanism involving the measurement of trans-substrate current, either through a current analysis circuit or a voltage and current analysis circuit, because none of these features is disclosed in either of Cross and Takagi.

Up until the present invention, it was considered virtually impossible to perforate brittle substrates using dielectric breakdown phenomena in a controlled manner. It is the merit of the present invention to have made such substrates amenable to a high precision controlled formation of holes/cavities/channels, using the combination of monitoring the trans-substrate current and the local application of heat to the region where the hole is to be formed. This is not taught or suggested in Cross which exerts no process control other than that the sparks are generated at a defined frequency, nor is it taught or suggested in Takagi which exerts some process control through voltage measurements, but the results of such control are relatively poor, and the process of Takagi cannot be extended to "difficult" substrates, such as substrates which are brittle at ambient temperature, e.g. glass.

Conclusion

In view of the foregoing amendments and remarks, Applicants assert that the pending claims are allowable. Their favorable reconsideration and allowance is respectfully requested.

Should the Examiner have any question or comment as to the form, content or entry of this Amendment, the Examiner is requested to contact the undersigned at the telephone number below. Similarly, if there are any further issues yet to be resolved to advance the prosecution of this application to issue, the Examiner is requested to telephone the undersigned counsel.

Please charge any fees associated with this paper to deposit account No. 50-3355.

Respectfully submitted,

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